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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
TANIGUCHI et al.

Application No. 09/697,678 | Art Unit: 2834

Filed: Octobber 27, 2000 | Examiner: M. Budd

For: ELASTIC WAVE GENERATOR

PENDING CLAIMS AFTER AMENDMENTS
MADE IN RESPONSE TO OFFICE ACTION DATED MAY 10, 2002

1. An elastic wave generator comprising:

an excitation coil;

a magnetostriction oscillator around which the excitation coil is wound and including laminated magnetostriction sheets having a metallic crystalline structure which exhibits positive strain characteristics in which length varies directionally upon magnetic excitation; and

a continuous metallic oscillator support substantially as ridgid as said magnetostriction oscillator, having first and second support surfaces in a continuous portion of said oscillator support, said first support surface directly abutting a first end surface of said magnetostriction oscillator, said first end surface intersecting a direction along which the length of said magnetostriction oscillator changes, and said second support surface directly abutting a second end surface of said magnetostriction oscillator, said second end surface intersecting the direction along which the length of said magnetostriction oscillator changes, said first and second support surfaces applying a compressive load to said magnetostriction oscillator, through shrink fitting of said magnetostriction between said first and second support surfaces, so that said magnetostriction oscillator is continuously supported and compressed by said first and second support surfaces when said magnetostriction oscillator changes in length between first said and second support surfaces due to the excitation of said excitation coil.

2. An elastic wave generator comprising:

an excitation coil;

a magnetostriction oscillator around which said excitation coil is wound and including laminated of magnetostriction sheets having a metallic crystalline structure which exhibits positive strain characteristics in which length varies directionally upon magnetic excitation;

a magnetic bias device having a magnetic path in common with said magnetostriction oscillator; and

a continuous metallic oscillator support substantially as ridgid as said magnetostriction oscillator, having first and second support surfaces in a continuous portion of said oscillator support, said first support surface directly abutting a first end surface of said magnetostriction oscillator, said first end surface intersecting a direction along which the length of said magnetostriction oscillator changes, and said second support surface directly abutting a second end surface of said magnetostriction oscillator, said second end surface intersecting the direction along which the length of said magnetostriction oscillator changes, said first and second support surfaces applying a compressive load to said magnetostriction oscillator, through shrink fitting of said magnetostriction between said first and second support surfaces, so that said magnetostriction oscillator is continuously supported and compressed by said first and second support surfaces when said magnetostriction oscillator changes in length between first said and second support surfaces due to the excitation of said excitation coil.

3. The elastic wave generator as claimed in claim 1, wherein substantially all magnetostriction energy generated in said magnetostriction oscillator upon excitation of said excitation coil becomes an internal stress at shrink-fit interfaces of said first and second end surfaces of said magnetostriction oscillator and said first and second support surfaces of said oscillator support.

4. The elastic wave generator as claimed in claim 1, wherein an internal stress at a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and an internal stress at a second shrink-fit interface of said second end surface of said magnetostriction oscillator and said second support surface of

said oscillator support are initially set compression stresses required for said magnetostriction oscillator.

5. The elastic wave generator as claimed in claim 2, wherein an internal stress at a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and an internal stress at a second shrink-fit interface of said second end surface of said magnetostriction oscillator and said second support surface of said oscillator support are stresses that provide, together with the magnetic bias produced by said magnetic bias device, initially set compression stresses required for said magnetostriction oscillator.

6. The elastic wave generator as claimed in claim 1, wherein a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and a second shrink-fit interface of said second end surface of said magnetostriction oscillator and said second support surface of said oscillator support are provided by elevating temperature of said magnetostriction oscillator after said magnetostriction oscillator has been cooled in a cryogenic environment and has been installed between said first and second support surfaces of said oscillator support.

7. The elastic wave generator as claimed in claim 1, wherein a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and a second shrink-fit interface of said second end surface of said magnetostriction oscillator and said second support surface of said oscillator support are provided by lowering temperature of said oscillator support after said oscillator support has been heated to an elevated temperature and said magnetostriction oscillator has been installed between said first and second support surfaces of said oscillator support.

8. The elastic wave generator as claimed in claim 1, wherein said magnetostriction oscillator is made by bonding said magnetostriction sheets to each other with a hardenable material to form an integral structure of said laminated magnetostriction sheets.

9. The elastic wave generator as claimed in claim 1, wherein said oscillator support includes a pocket having a first wall surface which intersects the direction along which the length of said oscillator changes, said first wall surface being one of said first and second support surfaces of said oscillator support, said pocket having a second wall surface which opposes said first wall surface and intersects the direction along the length of said oscillator changes.

10. The elastic wave generator as claimed in claim 1, wherein said oscillator support and said magnetostriction support are materials having substantially equal coefficients of thermal expansion.

11. The elastic wave generator as claimed in claim 1, wherein

said magnetostriction oscillator is made by bonding said magnetostriction sheets to each other to form an integral structure of said laminated magnetostriction sheets;

said oscillator support and said magnetostriction support are materials having substantially equal coefficients of thermal expansion; and

an internal stress at a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and an internal stress at a second shrink-fit interface of said second end surface of said magnetostriction oscillator and said second support surface of said oscillator support are initially set compression stresses required for said magnetostriction oscillator.

12. The elastic wave generator as claimed in claim 2, wherein

said magnetostriction oscillator is made by bonding said magnetostriction sheets to each other with a hardenable material to form an integral structure of said laminated magnetostriction sheets;

said oscillator support and said magnetostriction support are materials having substantially equal coefficients of thermal expansion; and

an internal stress at a first shrink-fit interface of said first end surface of said magnetostriction oscillator and said first support surface of said oscillator support and an internal stress at a second shrink-fit interface of said second end surface of said magnetostriction

oscillator and said second support surface of said oscillator support are stresses that provide, together with the magnetic bias produced by said magnetic bias device, initially set compression stresses required for said magnetostriction oscillator.

14. The elastic wave generator as claimed in claim 1, including an excitation current supplying device for energizing the excitation coil, said excitation current supplying device having an output that can be controlled by a sensor output.

15. A mounted magnetostriction oscillator comprising:

an object to which an elastic wave is to be imparted; and

a magnetostriction oscillator mounted to the object, wherein

said magnetostriction oscillator comprises an excitation coil wound around a stack of sheets of a metallic magnetostriction material bonded together with an electrically insulating bonding agent for generating an elastic wave in a direction parallel to said sheets in response to an excitation current flowing through said excitation coil,

said magnetostriction oscillator has two parallel surfaces intersecting at right angles with an elastic wave radiation direction and spaced apart from each other by a distance A at room temperature and a distance A1 at a temperature lower than room temperature,

the object has a hole or a recess having two parallel wall surfaces intersecting at right angles with the elastic wave radiation direction and spaced apart from each other by a distance B at room temperature,

A>B>A1 and B is approximately equal to (A- (2/3)(A-A1)), and

said magnetostriction oscillator is in direct contact with said wall surfaces and held in the hole or recess by compression forces generated by shrink-fitting said magnetostriction oscillator against said wall surfaces by cooling the magnetostriction oscillator to below room temperature, inserting said magnetostriction oscillator in the hole or recess, and then returning said magnetostriction oscillator to room temperature, said magnetostriction oscillator being continuously supported and compressed by said first and second support surfaces when said magnetostriction oscillator changes in length between first said and second support surfaces due to the excitation of said excitation coil.

16. The mounted magnetostriction oscillator as claimed in claim 15, wherein said object is a non-magnetic body.

17. The mounted magnetostriction oscillator as claimed in claim 16, wherein said object is a tubular body.

18. The mounted magnetostriction oscillator as claimed in claim 17, wherein said sheets of a metallic magnetostriction material include a curved sheet having a radius of curvature substantially equal to that of said tubular body.

19. The mounted magnetostriction oscillator as claimed in claim 17, wherein the recess or hole comprises a circumferential groove extending over all of a circumference of said tubular body.

20. The mounted magnetostriction oscillator as claimed in claim 17, wherein said tubular body is a drill pipe for drilling.

26. An elastic wave generator comprising:

an excitation coil;

a magnetostriction oscillator around which the excitation coil is wound and including laminated magnetostriction sheets having a metallic crystalline structure which exhibits positive strain characteristics in which length varies directionally upon magnetic excitation;

a spacer made of a non-magnetic material and located on a first end surface of said magnetostriction oscillator; and

a continuous oscillator support substantially as rigid as said magnetostriction oscillator, having first and second support surfaces in a continuous portion of said oscillator support, said first support surface directly abutting said spacer, said first support surface intersecting a direction along which the length of said magnetostriction oscillator changes, and a second support surface directly abutting a second end surface of said magnetostriction oscillator, said second support surface intersecting the direction along which the length of said magnetostriction oscillator changes, said first and second support surfaces applying a compressive load to said magnetostriction oscillator, through shrink fitting of said magnetostriction between said first and second support surfaces, so that said magnetostriction oscillator is continuously supported and compressed by said first and second support surfaces

when said magnetostriction oscillator changes in length between first said and second support surfaces due to the excitation of said excitation coil.